**Before the**
**FEDERAL COMMUNICATIONS COMMISSION**
**Washington, DC 20554**



| | | |
|---|---|---|
| In the matter of | ) | |
| | ) | |
| Amendment of the Commission's Rules to | ) | |
| Establish Rules and Policies Pertaining | ) | CC Docket No. 92-166 |
| to a Mobile Satellite Service in the | ) | |
| 1610-1626.5/2483.5-2500 MHz | ) | |
| Frequency Bands | ) | |

## COMMENTS OF ROCKWELL INTERNATIONAL CORPORATION

Pursuant to Section 1.415 of the Federal Communications Commission ("the Commission") Rules and Regulations, Rockwell International Corporation ("Rockwell") hereby submits an original and nine copies of Comments on the Notice of Proposed Rulemaking (NPRM) regarding Amendment of the Commission's Rules to Establish Rules and Policies Pertaining to a Mobile Satellite Service in the 1610-1626.5/2483.5-2500 MHz Frequency Bands. Rockwell's comments are confined to Interservice Sharing, particularly with Aeronautical Radionavigation Service and Radionavigation-Satellite Service.[1]

## INTRODUCTION

Rockwell's Collins Commercial Avionics Division is a manufacturer of land- and aeronautical-mobile satellite communications equipment and a reseller of satcom services.

[1] NPRM, Proposed Rule 25.313.

As noted in the Notice of Proposed Rulemaking,[2] Rockwell was also an active participant in the "MSS Above 1 GHz Negotiated Rulemaking Committee". As such, Rockwell wishes to see the Mobile Satellite Service (MSS) service become fully operational as quickly as possible. However, as a manufacturer of satellite radionavigation equipment, Rockwell is also concerned about the interservice sharing of MSS with Aeronautical Radionavigation Service and Radionavigation-Satellite Service.[3] Rockwell's specific concerns are with the proposed MSS in-band radiated power and the lack of adjacent band emission limits as they impact the Russian Global Navigation Satellite System ("GLONASS") which currently operates in the 1602-1616 MHz band.

## DISCUSSION

### In-Band Radiated Power

GLONASS is planned to be a principal component, along with the Global Positioning System (GPS), in the International Civil Aviation Organization's (ICAO) Global Navigation Satellite System (GNSS) for "sole means" aircraft navigation. As such, GLONASS is to be protected from harmful interference under International Radio Regulation RR732.[4] In the proposed new Part 25.213(c) the MSS in-band (1610-1616 MHz) effective isotropic radiated power (e.i.r.p.) is proposed to be -15 dB(W/4 kHz). This power density level is

---

[2] NPRM, Section II.9, footnote 20, p. 6.

[3] NPRM, Section III.B.2, pp. 29-31.

[4] Id., paragraph 53, p 29.

approximately 140 dB above the maximum interference level tolerated by a standard GLONASS receiving system. The MSS interference must be attenuated by a combination of free space path loss and relative GLONASS antenna directivity. GLONASS antenna directivity can be expected to attenuate the MSS interference between 20 and 0 dB relative to the GLONASS satellite signals. The remaining attenuation requires from **14.8 to 148 km** free-space separation between the MSS transmitter and the GLONASS receiver to permit tracking of the GLONASS signal. Since air routes and approach paths are relatively dense in the United States compared to this range of separation distances (c.f. Attachment 1, attached hereto and made a part hereof),[5] shared use of the band segment is impractical to achieve without significant operational constraints on either MSS or GLONASS. Efforts are underway to revise the occupied band of GLONASS[6] such that operation would be shifted below 1610 MHz. Rockwell fully supports this effort in order to promote spectrum efficiency and to free up spectrum for MSS use. However, in order to protect GLONASS from harmful co-channel interference until it is shifted below 1610 MHz, MSS operation should not be permitted in the band segment 1610-1616 MHz.

**Adjacent Band Emissions**

The proposed new Rule 25.213 does not provide any out-of-band emission limits on MSS equipment to protect GLONASS receivers operating in the 1602-1610 MHz band. Limits

---

[5] Attachment 1, "An Analysis of Protection Zones for MSS-L-Band Uplink/GLONASS Frequency Sharing During Enroute Navigation," was previously submitted by Rockwell in the MSS Above 1 GHz Negotiated Rulemaking Committee, Informal Working Group (IWG) 2, as Document IWG2-76.

[6] NPRM, Section III.B.2, paragraph 57, p. 31.

of -80 dB(W/MHz) for narrowband transmissions and -70 dB(W/MHz) broadband transmissions are, however, provided to protect GPS receivers operating at 1575.42 MHz.[7] Attachment 2 (attached hereto and made a part hereof) clearly shows that, due to similar system characteristics, the same MSS narrowband and broadband emission limits, if applied over the 1602-1610 MHz, would provide similar protection for GLONASS operation. The analysis shown in Attachment 2 is consistent with the analysis put forth in Attachment B of Annex II of the "Report of the MSS Above 1 GHz Negotiated Rulemaking Committee (April 6, 1993)".[8] Interference rejection characteristics of combination GPS and GLONASS airborne receivers as specified in ARINC Characteristic 743A-1 are most sensitive to interference in the frequency range 1560-1610 MHz. It is, therefore, recommended that proposed Rule 25.213(b) be modified to widen the protected frequency range to 1560-1610 MHz. This wider range more fully protects GPS and GLONASS compared to the minimum range presently proposed for GPS only; i.e., 1574.397-1576.443 MHz.

## CONCLUSION

In order to protect GLONASS from harmful co-channel interference, Rockwell recommends that proposed Part 25.213(c) specifically provide that MSS operation not be permitted in the band segment 1610-1616 MHz until such time as GLONASS is shifted below 1610 MHz. In addition, Rockwell urges the Commission to amend Part 25.213(b)

---

[7] NPRM, Proposed Rule 25.213(b)

[8] NPRM, Section II.9, footnote 23, p. 7.

to widen the protected frequency range from the proposed 1574-397-1756.443 MHz to 1560-1610 MHz in order to more fully protect both GPS and GLONASS from out-of-band emissions.

Respectfully submitted,

By: Linda C. Sadler

Linda C. Sadler
Manager, Governmental Affairs
Rockwell International Corporation
1745 Jefferson Davis Highway
Arlington, VA 22202
Telephone: (703) 412-6696

May 4, 1994

ATTACHMENT 1

(previously submitted as MSS Advisory Committee Working Paper IWG2-76)

# AN ANALYSIS OF PROTECTION ZONES FOR MSS L-BAND UPLINK / GLONASS FREQUENCY SHARING DURING ENROUTE NAVIGATION

One potential means of protecting airborne GLONASS navigation from interference due to co-frequency ground-based MSS uplink transmissions is through the use of exclusion or protection zones around critical GLONASS operational areas. In addition to the final approach paths into airports, two other types of critical areas are the approach navigation signal capture points (enroute transition to final approach) and general enroute flight paths. The case of final approach interference has been covered in other documents (e.g., IWG2-27). This report will present a derivation of protection zone radius based on free-space propagation and apply it to the two types of enroute scenarios.

If maximum emission levels for co-frequency MSS uplinks and GLONASS receiver interference immunity levels are known, then separation range can be calculated assuming free space propagation between unity gain isotropic antennas. The unity gain assumption is a reasonable upper bound given limited fuselage pertubations to the normal upward looking aircraft antenna pattern. Table 1 lists the EIRP and occupied bandwidth of the five systems proposing co-channel operation with GLONASS. The power spectral density (PSD) for each was found by simply dividing EIRP by the bandwidth. The free-space separation ranges in the table are found by assuming a maximum interference level of -190 dBW/Hz for a GLONASS receiver and computing the range for the free-space path loss required to reduce the PSD to that value. The -190 dBW/Hz value corresponds to a C/(No+Io) of 29 dB-Hz which is for loss-of-track. Note that large free-space separations are required.

Table 1 MSS - GLONASS Co-Channel Interference Protection Zones Radii

| SYSTEM | EIRP (dBW) | BW (kHz) | PSD (dBW/Hz) | RANGE @ -190 dBW/Hz |
|---|---|---|---|---|
| ELLIPSAT | 4.0 | 1100 | -56.4 | 70.5 km |
| CONSTEL | 0.6 | 16500 | -71.6 | 12.3 km |
| LQSS | -4.0 | 1250 | -65.0 | 26.3 km |
| TRW | 0.0 | 4833 | -66.8 | 21.3 km |
| CELSAT | -9.0 | 1250 | -70.0 | 14.8 km |

Note that these CDMA and other MSS systems also propose to operate immediately above the 1616 MHz upper GLONASS frequency limit with the same EIRP levels as in Table 1. As such, their off-channel emissions would have to drop rapidly with frequency separation to avoid the large separations required for co-frequency operation.

To visualize the impact of the large separation ranges on co-frequency MSS operation near an approach navigation capture point, consider the situation for Los Angeles International (Figure 1). The capture point is plotted at 37 km east of the end of Runway 26L where the aircraft is ideally at 1900 m altitude. Two circles are plotted on the ground with slant ranges to the aircraft of 15 and 30 km, respectively corresponding roughly to values in Table 1. Note the large populated areas which would have to be excluded from MSS operation just to protect that one point from the emissions of one uplink transmitter. The protection zone would be still larger to protect the flight paths approaching the capture point from the east, north, and south even if GLONASS was not used in final approach navigation. The situation for most other large metropolitan airports is much the same. As a result the use of protection zones to eliminate co-channel MSS uplink interference to GLONASS reception is very impractical since it would exclude co-channel MSS use from very large portions of the large metropolitan areas.

Enroute navigation is done over a whole range of altitudes below 1500 m to more than 15000 m. Since it has been suggested that the EIRP limit of -15 dBW/4 kHz in WARC-92 Footnote 731E was derived on the basis of a high altitude enroute navigation application, consider next the situation for enroute paths over the sparcely populated Western US. One such area, as illustrated by Jeppesen Chart US (LO) #7 ( Figure 2.), is roughly from Western Kansas to Central Utah and Northern Colorado to Northern Wyoming. Points A-D are Jackson, WY, Rapid City, SD, Denver, CO, and Salt Lake City, UT, respectively. Ground corridors are plotted under a few high altitude jet routes within which the slant range to an aircraft is less than 30 km ( at altitudes between 18000 and 37000 ft). The inside of the corridors is indicated by inward crosshatching. Note the small space remaining outside the corridors. This space would be even further reduced if the remaining jet routes and the low altitude routes were also guarded with exclusion corridors. Corridors in the more populated regions are would be so densly packed as to prevent all MSS uplink operation. Thus fixed exclusion zones around enroute aircraft flight paths are quite impractical.

If the protection is provided through the use of beacons carried aboard the aircraft, the MSS operation area near enroute paths would be significantly increased. This solution, however, is also very impractical due to the high cost of beacon system installation and maintainance. A high reliability, dual frequency (L-/S-Band) beacon system would be needed on all aircraft which intend to use GPS/GLONASS as a primary navigation system. Not only would Air Transport category aircraft need the dual frequency beacon system, but large numbers of General Aviation aircraft, as well, which are much less able to absorb the extra cost.

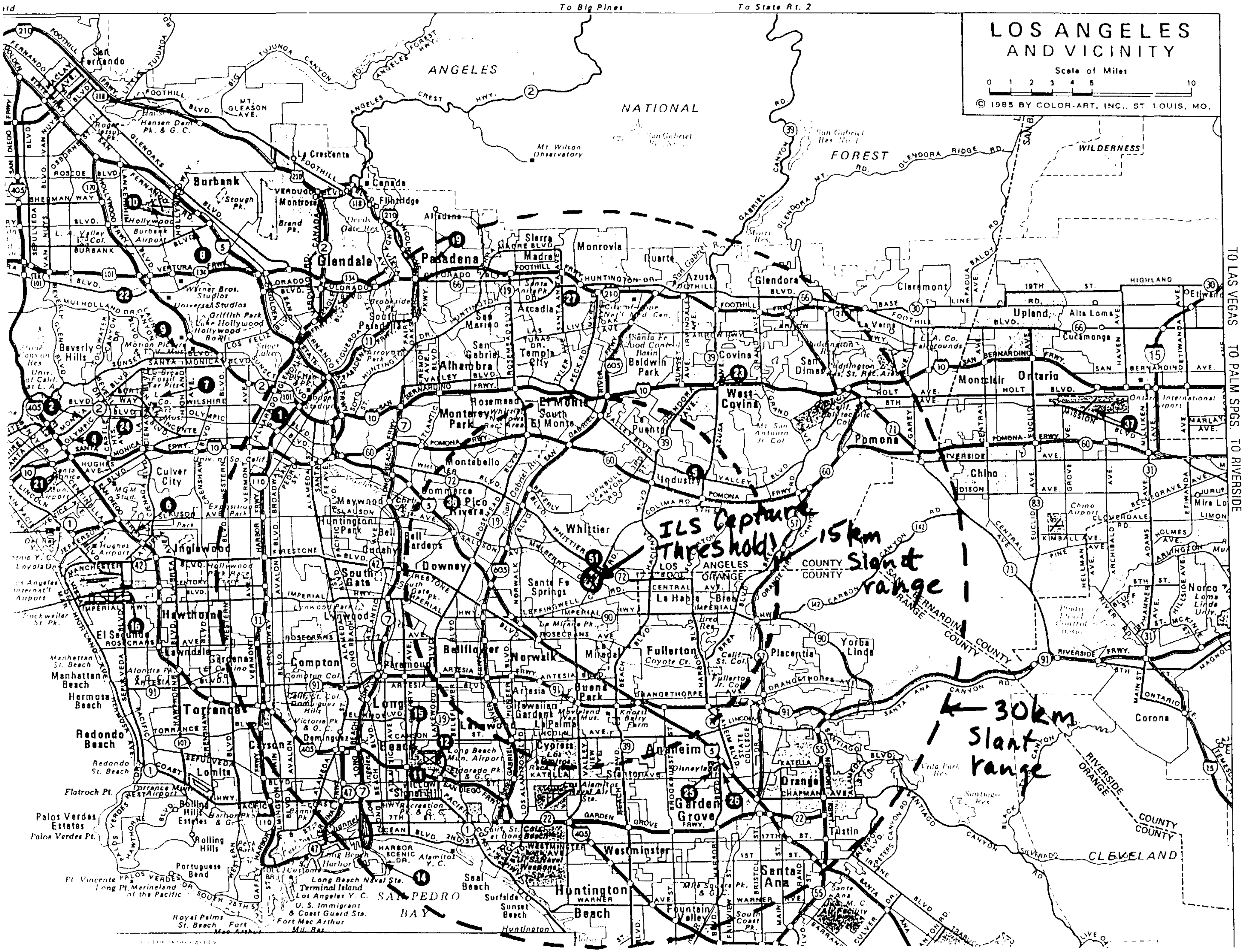


FIGURE 1. TYPICAL LOS ANGELES AREA PROTECTION ZONES

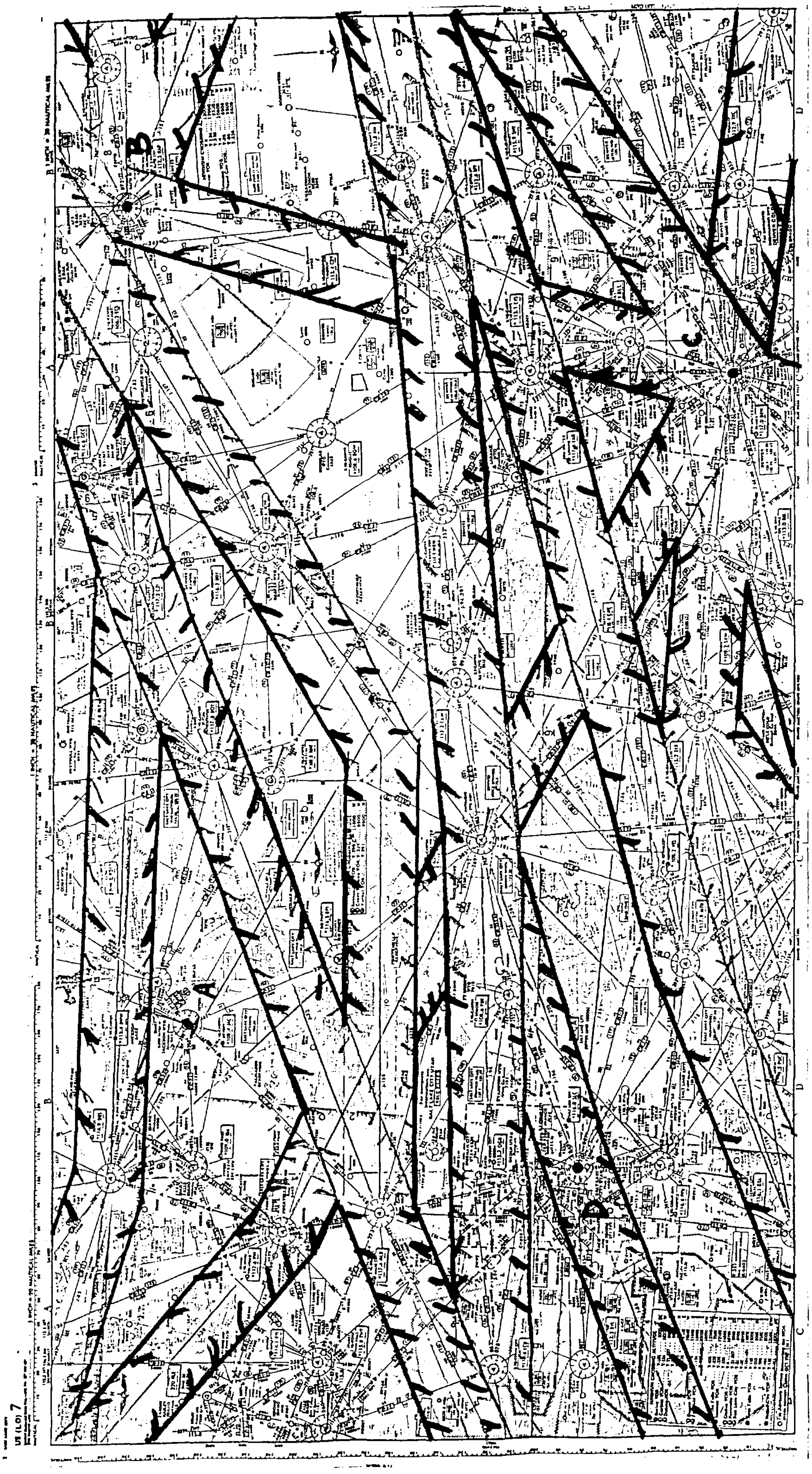

FIGURE 2. TYPICAL WESTERN CONUS ENROUTE PROTECTION ZONES

ATTACHMENT 2

# MSS MOBILE EARTH STATION OUT-OF-BAND EMISSION LIMITS FOR PROTECTION OF GPS AND GLONASS STANDARD POSITIONING SERVICES

NAVIGATION RECEIVER SYSTEM PARAMETERS:

System Noise Temperature (referenced to antenna)

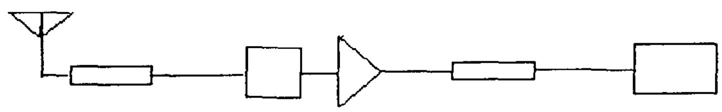


Figure 1. Nav Receiver System Block Diagram

$T_{sky} := 100$ Kelvins, environment noise temperature

$T_c := 300$ Kelvins, antenna ohmic and cable loss temperature

$T_o := 290$ Kelvins, noise figure standard reference temperature

$L_c := 10^{\frac{1.5}{10}}$ antenna ohmic and cable loss factor (ratio)

$F_p := 10^{\frac{2.544}{10}}$ remote preselector/preamp input noise factor (ratio)

$T_{sys} := T_{sky} + T_c \cdot (L_c - 1) + L_c \cdot [(F_p - 1) \cdot T_o]$ System noise temperature (referenced to antenna)

$T_{sys} = 549.99$ Kelvins. Assume the same value at 1575.42 MHz and 1602-1616 MHz.

Antenna Directivity Factors

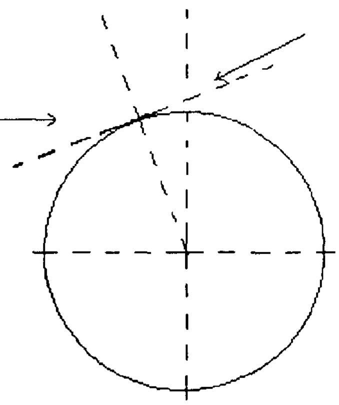


Figure 2. Jammer - Satellite Geometry for 20 degree Aircraft Roll Manuever

Angles relative to antenna:
Jammer Angle = +20 deg.
Satellite Angle = +5 deg.

Min. spec. directivity, 5 deg. $D_s := -4.5$ dB

Assume directivity, 20 deg. $D_j := 2.5$ dB

Relative jammer-satellite directivity for 20 degree roll $D_j - D_s = 7$ dB

<u>Signal Processing Factors</u> $i := 1..2$ signal index

$S_1 := -161$ dBW, Minimum GLONASS signal (ref. to 0 dBic antenna)

$S_2 := -160$ dBW, Minimum GPS L1 C/A signal

$GBw_1 := 10 \cdot \log\left(5.11 \cdot 10^5\right)$ dB-Hz, GLONASS processing gain-bandwidth, wideband noise

$GBn_1 := GBw_1 - 5.08$ dB-Hz, GLONASS gain-bandwidth, narrowband (<600 Hz) jammer

$GBw_2 := 10 \cdot \log\left(1.023 \cdot 10^6\right)$ dB-Hz, GPS processing gain-bandwidth, wideband noise

$GBn_2 := GBw_2 - 16.1$ dB-Hz, GPS gain-bandwidth, narrowband (<600 Hz) jammer

$CNIR := 32$ dB-Hz, Minimum carrier/(noise+interference) ratio for acquisition with dwell time < 40 ms - a long but bearable dwell given nav. is underway

$L_{imp} := 2.5$ dB, Hardware implementation loss - for non-ideal filtering, A/D thresholds, etc.

MAXIMUM RECEIVER INTERFERENCE LEVEL CALCULATIONS: (Ref. ARINC 743A-1)

<u>Wideband Power Density Calculation</u>

$N_o := 10 \cdot \log\left(1.38054 \cdot 10^{-23} \cdot T_{sys}\right)$ dBW, System ambient noise power at antenna

$N_o = -201.2$

$$JBDw_i := S_i + 10 \cdot \log\left(10^{\frac{-L_{imp} - CNIR}{10}} - 10^{\frac{N_o - S_i - D_s}{10}}\right)$$

= Product of wideband interference power density and relative int./sig. antenna directivity, rearranged log form of: C/(No+Io) = S*Ds/Limp/(No+J*Dj/GB)

$JBDw_1 = -201.68$ dBW/Hz, Max. GLONASS wideband interference power density at antenna for 0 dB relative interference/signal antenna directivity

$JBDw_2 = -198.51$ dBW/Hz, Max. GPS wideband interference power at antenna (0 dB I/S dir.)

<u>Narrowband Power Calculation</u>

$$JDn_i := S_i + GBn_i + 10 \cdot \log\left(10^{\frac{-L_{imp} - CNIR}{10}} - 10^{\frac{N_o - S_i - D_s}{10}}\right)$$

= Product of narrowband interference power and relative int./sig. antenna directivity, log form from wideband case multplied by narrowband proc. gain-bandwidth factor

$JDn_1 = -149.68$ dBW, Max. GLONASS narrowband interference power at ant. for 0 dB relative interference/signal antenna directivity

$JDn_2 = -154.51$ dBW, Max GPS narrowband interference power at antenna (0 dB I/S dir.), consistent with ARINC Characteristic 743A-1

SEPARATION RANGE CALCULATION:

<u>Maximum Out-of-Band MSS Emitted Power Definition</u>

$Pdw := -130$ dBW/Hz, Max. MES o-o-b emitted EIRP density in GPS L1 or GLONASS band for interference with more than 600 Hz bandwidth, equivalent to -70 dBW/1MHz

$Pn := -80$ dBW, Max. MES o-o-b emitted EIRP in GPS L1 or GLONASS band for interference with less than 600 Hz bandwidth

Free-Space Range Calculation

$m := 1 .. 11$ calculation index

$Djs_m := -3 + (m - 1)$ dB, Relative jammer-to-signal antenna directivity (indexed)

$A_1 := 20 \cdot \log\left(\frac{.2997925}{1.602 \cdot 4 \cdot \pi}\right)$ $A_2 := 20 \cdot \log\left(\frac{.2997925}{1.57542 \cdot 4 \cdot \pi}\right)$ dB, Capture area factors, GLONASS, GPS

$Rw_{m,i} := 10^{\frac{Pdw - JBDw_i + Djs_m + A_i}{20}}$ meters, Separation range for wideband interference

$Rw_{11,1} = 128$ $Rw_{11,2} = 90.34$ GLONASS, GPS ranges, respectively, in meters for 7 dB directivity favoring the wideband interference

$Rn_{m,i} := 10^{\frac{Pn - JDn_i + Djs_m + A_i}{20}}$ meters, Separation range for narrowband interference (bandwidth < 600 Hz)

$Rn_{11,1} = 101.62$ $Rn_{11,2} = 180.28$ GLONASS, GPS ranges, respectively, in meters for 7 dB directivity favoring the interference

Table 1. Wideband and Narrowband Interference Separation Ranges as a Function of Relative Interference/Signal Antenna Directivity

| Rel I/S Direct. (dB) $Djs_m$ | GLONASS WB Int. $Rw_{m,1}$ | GLONASS NB Int. $Rn_{m,1}$ | GPS WB Int. $Rw_{m,2}$ | GPS NB Int. $Rn_{m,2}$ |
|---|---|---|---|---|
| -3 | 40.48 | 32.14 | 28.57 | 57.01 |
| -2 | 45.41 | 36.06 | 32.05 | 63.97 |
| -1 | 50.96 | 40.46 | 35.97 | 71.77 |
| 0 | 57.17 | 45.39 | 40.35 | 80.53 |
| 1 | 64.15 | 50.93 | 45.28 | 90.35 |
| 2 | 71.98 | 57.15 | 50.8 | 101.38 |
| 3 | 80.76 | 64.12 | 57 | 113.75 |
| 4 | 90.61 | 71.94 | 63.96 | 127.63 |
| 5 | 101.67 | 80.72 | 71.76 | 143.2 |
| 6 | 114.08 | 90.57 | 80.52 | 160.67 |
| 7 | 128 | 101.62 | 90.34 | 180.28 |

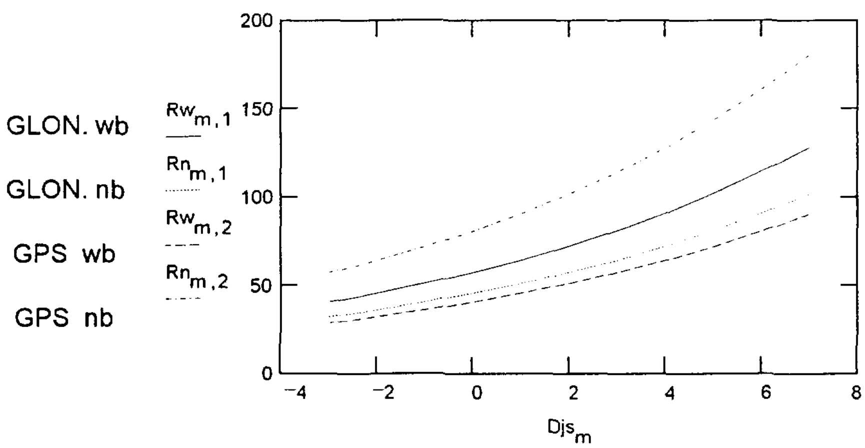


Figure 3. Separation Range vs I/S Antenna Directivity (cases from Table 1)